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Book review

**Alexander Gegov, Complexity Management in Fuzzy Systems, 2007, 368 pp. Hardcover: Studies in Fuzziness and Soft Computing, Volume 211; • €89.95 | £69.00; ISBN-10: 3-540-38883-4; ISBN-13: 978-3-540-38883-8.**

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Prof. Gegov's book is a timely contribution to a very rapidly evolving field—as he terms it, the field of complexity management. However, his book is focused at the management of fuzzy rule based systems and, while such systems often represent complex systems, the field is broader than this. A more appropriate, and more accurate, title might have been:

**Fuzzy rule bases: Formalisms, transformations, simplifications and reductions**

Nevertheless this book would be an important addition to the library of anyone doing serious work in the development of fuzzy systems. The reason is simple: fuzzy logic is the logic used in systems of high complexity (as opposed to binary logic's use in systems of low complexity), and such systems require methods to reduce, in some sense, the complexity associated with system description. The presumption of the book, of course, is that complex systems are described by many rules which can be inconsistent, non-monotonic, or in some sense dissonant. When one accepts this as a basis for describing a system, then Prof. Gegov's book is a must-read.

A fuzzy system is any system for modeling, simulation, control, prediction, diagnosis, decision-making, pattern recognition, or image processing which uses fuzzy logic and fuzzy rules. Complexity of such a system arises when the size of the rule-base increases, thereby offering more opportunity for dissonance within the rule base. We should recognize that dissonance, confusion, ambiguity and conflict are the features of a system which make them complex in the first place. A very simple system does not need fuzzy logic for its description or use.

Alternatively, complexity management in the context of this book can be thought of as a protocol to use fuzzy systems more effectively and efficiently in solving complex problems. One area of interest to many researchers is the field of computational complexity, where long-standing problems still have not been solved. For example, the use of supercomputers in cosmology and genetics still have not resolved critical problems, and threats from terrorism and natural disasters involve massive amounts of information too large to process even on the fastest computers. Computers are set up essentially to solve physics at a single point or cluster in space, and not to address issues that are ambiguous and amorphous in space and time.

Systems which are highly complex exhibit two key features: 1) their quantitative dimension in terms of number and scale, and 2) their qualitative dimension in terms of ambiguity and uncertainty. Computers can be used to address the first feature to a limited extent based on the capacity of the hardware and software, but they are not yet suited to address the second feature. The author distinguishes his book from most others in this field by stating that he emphasizes dealing with the second feature, and not the first. He makes the following statement: "*It is not surprising that research in fuzzy systems has been focused mainly on quantitative complexity issues. After all, it is normal to expect current research methodologies to be strongly affected by the dominant profit orientated values in our society and the associated material targets such as improved efficiency and increased productivity. This is why most of the*

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*known methods dealing with complexity in fuzzy systems are aimed primarily at reducing the time for the completion of the required computations. This book preaches a different philosophy*."

The author begins his book with a listing of the canonical rule forms: Mamdani, Sugeno and Tsukamoto. Chapter 3 introduces the reader to the most common form of rule-based reduction methods—the Hierarchical System (HS). Several of the chapters show how qualitative aspects of the rule-base are reduced to numerical quantities using certain methods of inference and deductive reasoning. Once this is done, however, computational efficiencies must be realized to reduce complexity. Most of the chapters (Chs. 4–8) provide methods to organize the rule bases, to simplify them, and to identify rules that contain issues of complexity: rules that contain conflict, inconsistencies, non-monotonicity and dissonance. Chapter 9 is the "beef" of the book. It is here that the author compares methods to reduce these issues of complexity. In this chapter there are two specific case studies that show the superiority of Gegov's method, called Filtered Systems (FS), when compared to two rule formalisms: Hierarchical (HS) and Classical Systems (full rule-base with no simplifications or reductions). Gegov shows how the power of his FS approach becomes even more evident as the size of the rule-base increases. While he shows this only for Mamdani inference rules, he describes how the same trends will be seen for Sugeno and Tsukamoto inference schemes.

Despite my positive critique of this work there were a couple nagging issues. First, the use of Zadeh's notation to describe fuzzy membership functions, instead of simple figures, makes the book very onerous to read and study. The use of figures throughout would make this text more readable; for example, the simple notion of symmetry is easier to see than to compute in one's head. Second, some of the examples could have used actual linguistic forms instead of the ubiquitous use of simple numerical values from the various membership functions.

I had a PhD student who did some similar work in the area of rule-reduction methods about 3 years ago who could have benefited immensely from the material now available in Prof. Gegov's work. I am happy to see that some of the research in this area is finally making its way, in a collected and organized fashion, into books like this one. This book will help many serious practitioners make fuzzy systems a more compact and efficient modeling approach to deal with complex systems which are described by a large number of rules.